How to Avoid Costly Failures in LNG and Oil & Gas Due to Degradation and Failure of Protective Coatings

By PCN Editor

In the high-stakes industries of LNG and Oil & Gas, protective coatings play a crucial role in preventing corrosion and maintaining asset integrity. However, the selection and performance of these coatings are often underestimated, leading to significant risks of premature failure and costly operational disruptions.

LNG and Oil & Gas projects will start with a protective coating specification where typically up to 6 commercially available coatings are specified along with DFT and number of coats. These are generally the most suitable grades from the following major coating suppliers: Akzo Nobel, Hempel, Jotun, PPG, Chugoku, Sherwin Williams, Carboline etc.

It is assumed that all these specified coatings are deemed '*equivalent*' and '*fit for purpose*'. The reality however is that certain coatings have significant performance benefits over others because of the way they are formulated and manufactured in terms on the level of type of barrier pigments and the quality and reactivity of the epoxy binders. Furthermore, certain coatings can better resist aggressive service conditions better than others and this cannot just be simply deduced from a desk audit of technical datasheets.

In order to eliminate arbitrary selection of the coating based on basic factors such as cost and easy availability rather than performance and long-term durability it is highly recommended that comparative coating trials (CCT) are performed using test plates. These trials are also known as product qualification trials (PQT). It is surprising how often even on million/billion dollar projects that PQT of protective coatings is not performed.

The use of test plates also allows the coatings to be exposed to the specific combination of environmental factors present are the intended service site.

Such test plates are mild steel of the type used in the final service application that are blasted and prepared as per the project specification and then coated with the specified number of coats at the specified thickness and lastly cured according to the manufacturer's recommendations. Furthermore additional test panels can be coated with variations from the specification such as inadequate number of coats or too thin or too thick coating build and/or under curing.

The coated test panels are then exposed to the following environmental factors both individually and in combination to create a testing matrix to show what circumstances can leads to premature coating failure:

- Heat by Oven ageing
- Dry UV by QUV ageing
- Dry/wet UV by QUV ageing with condensation cycle
- Salt Spray by Salt Spray Chamber
- Immersion by Immersion bath

Finally the use of Electrical Impendence Spectroscopy (EIS) allows the breakdown in the barrier properties of the coating to be quantified and hence the degree of coating degradation can be directly compared in terms of % retained impedance or % loss of impedance. Such testing gives a wealth of predictive data on expected coating lifetime and likely premature failure modes.

The results of the plate trials can then be analysed by the three different AI programs below to look for correlations and predict failure modes.

Gaussian Process Regression (GPR) is a powerful and flexible non-parametric regression technique used in machine learning and statistics. It is particularly useful when dealing with problems involving continuous data, where the relationship between input variables and output is not explicitly known or can be complex.

Relevance vector regression (RVR) is a useful tool for degradation modelling and remaining useful life (RUL) prediction.

Support Vector Regression (SVR) is a machine learning algorithm used for regression analysis. SVR Model in Machine Learning aims to find a function that approximates the relationship between the input variables and a continuous target variable while minimizing the prediction error.

Without such trials the optimum selection of a protective coating is a lottery. Instead by running side-by-side coating trials it is akin to knowing the outcome of a horse race where the coating performance has been directly compared and ranked.

ExcelPlas Coatings Labs are a one-stop shop for preparation of the steel test panels, the application of the coatings, accelerated environmental testing, EIS assessment and big data analysis to de-risk your net coating project in LNG and Oil & Gas.

Conclusions and Key Take-Ways

Protective coatings are not created equal. While project specifications often list several approved coatings, assuming their equivalence can be misleading. Variations in formulation, quality of ingredients, and manufacturing processes can lead to substantial differences in performance and durability under real-world conditions. Factors such as resistance to aggressive environments and long-term adhesion are critical but not always apparent from technical datasheets alone.

To mitigate the risks associated with arbitrary coating selection based solely on cost or availability, conducting Comparative Coating Trials (CCT) is highly recommended. These trials, also known as Product Qualification Trials (PQT), involve applying specified coatings onto test plates that mimic the intended service environment.

Process of CCT:

• Test Plate Preparation: Mild steel plates are prepared according to project specifications, including surface blasting and preparation.
• Coating Application: Each selected coating is applied with the specified number of coats and thickness, following manufacturer guidelines.
• Environmental Exposure: Test plates are exposed to various environmental stressors either individually or in combination. These include heat (oven aging), UV exposure (QUV aging), salt spray (salt spray chamber), and immersion (immersion bath).

Benefits of CCT:

• Realistic Simulation: Test plates replicate actual service conditions, providing insights into how coatings perform over time.
• Identifying Failure Modes: By varying coating thickness or curing conditions on additional test panels, potential failure modes can be identified and understood.
• Predictive Data: Electrochemical Impedance Spectroscopy (EIS) is employed to quantify barrier properties and predict coating lifetime and degradation rates.

Analyzing Results with AI:

To enhance the reliability and predictive power of CCT results, advanced data analysis techniques such as Artificial Intelligence (AI) can be employed:
• Gaussian Process Regression (GPR): Utilized for modeling complex relationships in continuous data, helping to predict coating performance based on environmental exposures.
• Relevance Vector Regression (RVR): Particularly useful for degradation modelling and predicting Remaining Useful Life (RUL) of coatings.
• Support Vector Regression (SVR): Enables precise regression analysis, minimizing prediction errors between input variables and target outcomes.

ExcelPlas Coatings Labs offer comprehensive services essential for effective CCT:
• Panel Preparation: Expert preparation of steel test panels ensuring adherence to project specifications.
• Coating Application: Precise application of coatings with attention to recommended thickness and curing.

- Accelerated Testing: Environmental exposure testing to simulate harsh conditions and accelerate aging processes.
- EIS Evaluation: Detailed assessment using Electrochemical Impedance Spectroscopy to quantify coating degradation.

In conclusion, the selection of protective coatings in LNG and Oil & Gas projects should not be left to chance. By conducting Comparative Coating Trials supported by advanced AI analysis and comprehensive laboratory testing, stakeholders can mitigate risks, optimize performance, and ensure long-term asset integrity.

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provide a crucial role in this process, offering a holistic approach from preparation and application to rigorous testing and predictive analytics. Investing in thorough coating evaluation upfront is not just prudent but essential for safeguarding against costly failures in critical infrastructure.

By adopting these practices, stakeholders can ensure that protective coatings not only meet but exceed performance expectations, thereby safeguarding investments and enhancing operational reliability in demanding industrial environments.